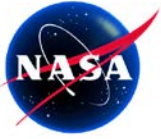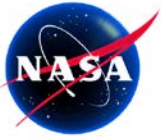# Modem Link-Property Advertisements

William D. Ivancic

Lloyd Wood

Dan Shell

Daniel Floreani

Rajiv Asati

# Cognitive Networks and Radios

- <u>Autonomous system</u> – perceives current conditions, and then plans, decides, and acts on those conditions based on predefined rules and algorithms.

- <u>Cognitive system</u> – **LEARNS** from the consequences of its actions and uses this knowledge to improve the future decisions (instead of just predefined rules/algorithms)
  - Feedback is required
  - Need to establish good metrics
  - Learning takes time

- Radio Networks should be cognitive for true adaptability and dynamism and be aware of its environment.
  - Thus, technologies must be developed that expose radio parameters to rest of network and provide methods for adjusting those parameters.
    - Example - Modem Link-Property Advertisements
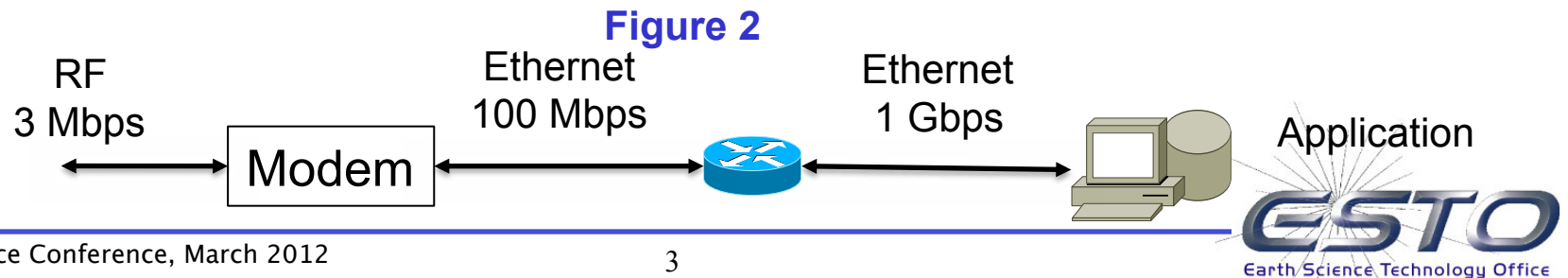
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Smart Modems

- Modem's transmitting and receiving link rates can be varied over time due to the following:
  - Adaptive coding
  - Changes in Modulation to suit radio channel characteristics.
  - Changes in transmission rate to suit radio channel characteristics

- Rate mismatch between RF link and Ethernet link.
  - Serial connections are less of a problem as clocks can be controlled by modem (at least the receiving clock)
  - Ethernet connections are becoming standard and result in rate mismatch between the LAN interface and the RF link.

RF
3 Mbps

Modem

Ethernet
100 Mbps

Ethernet
1 Gbps
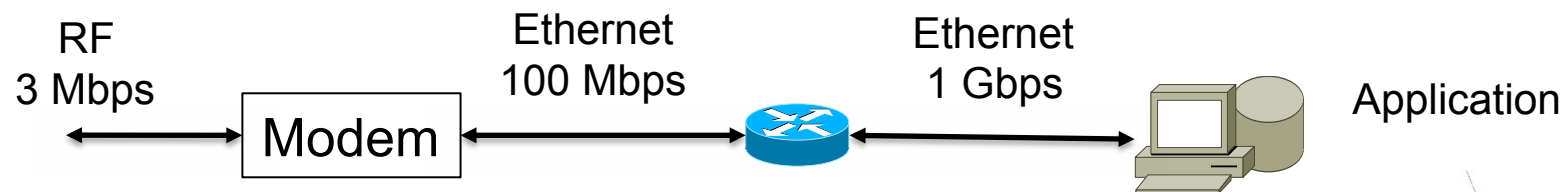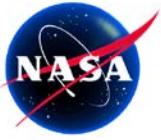
Application

Issue / Problem

- To condition traffic and get the most out of the modem's link capacity, routers & applications need to know the modem's link conditions.
  - Figure 1 corresponds to existing commercial imaging satellites
  - Figure 2 is more generic
- Desire is to have a standard method for the upstream devices (router and host applications) to learn of the link conditions and adjust
  - Link Up/Down
  - Link Unreliable
  - Data Rates

Figure 1

RF
3 Mbps

Modem

Serial
Link

Application

Figure 2

RF
3 Mbps

Modem

Ethernet
100 Mbps

Ethernet
1 Gbps

Application

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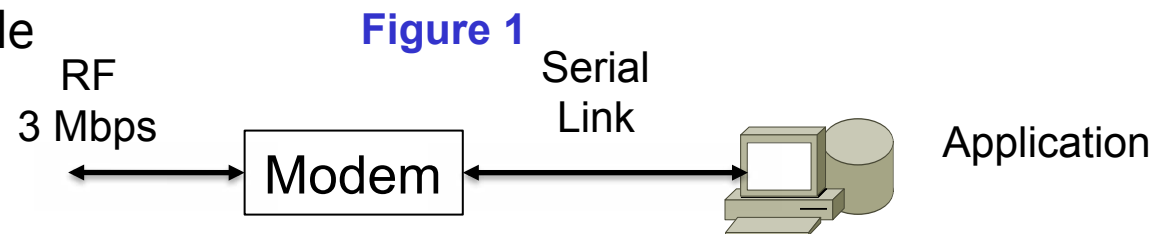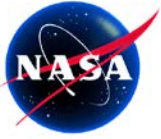
Solution

- **Develop a standard protocol that provides link status conditions**
  - Should be able to provide wide area network (WAN) radio reachback link status to routers and upstream devices/applications that may be multiple hops away.

- **Uses**
  - Applications can adjust to link state
  - Route Optimization
    - Useful for multi-homed systems

RF 256 kbps — Modem — Ethernet 100 Mbps

RF 3 Mbps — Modem

Application

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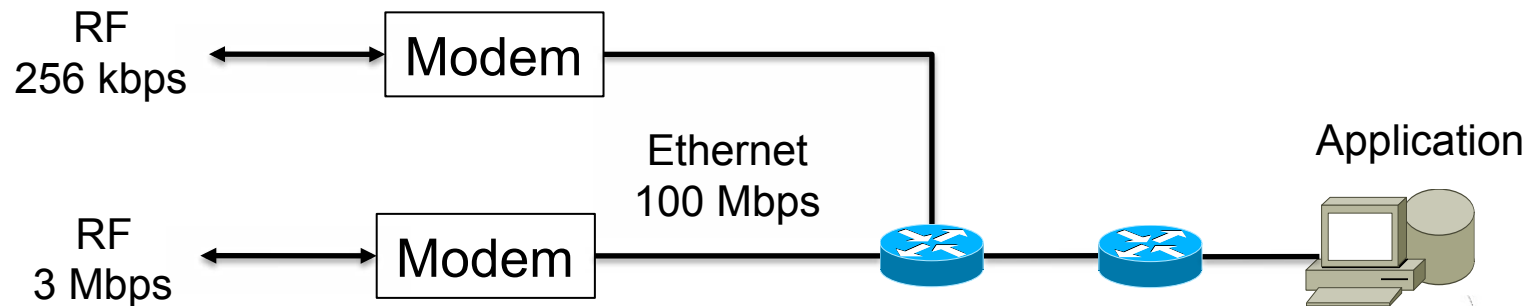
Crypto/Router

- Red/Black Separation
- Rate Mismatch Problem
- It is hard to sense the real rates offered through "the system".
  - It is feasible for such devices to work this out on their black side - and the red side and can simply advertise the "offered rate".
  - The Black side obtains knowledge of its downstream link state via modem advertisements, router advertisements, or probes, and pass this on to the red side via approved methods.
  - The red side can then advertise its rate via the LPA protocol.

Effective Throughput 10 Mbps

Ethernet 100 Mbps

Crypto
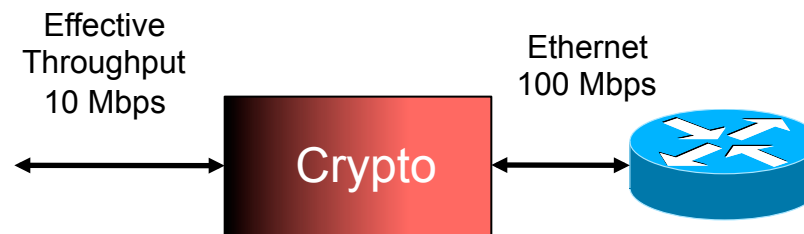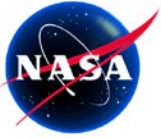
Strategy

- Released public request for participation to radio system providers and information system manufacturers
- Starting Points
  - RFC-5578, PPP over Ethernet (PPPoE) Extensions for Credit Flow and Link Metrics
    - Informative Document
    - Similar Idea, but very complex with to many parameters that cannot be set well.
  - Dynamic Link Exchange Protocol (DLEP) (draft-ietf-manet-dlep-00)
    - Similar to RFC-5578, but does not utilize PPPoE
    - Router centric
    - Session oriented
  - Link properties advertisement from modem to router (draft-wood-dna-link-properties-advertisement-01)
    - Uses UDP multicast to advertise link characteristics
    - Simple
- Demonstrate usability in C or C++ implementation of Saratoga
  - Listen for on multicast channel to set rate-limit
  - Can test in Global Hawk Protocol Testbed.
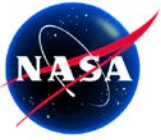
Protocol Concepts

- ## Advertise Modem's link conditions over IP/UDP
  - Link-local IP multicast advertisements from Modem
    - No need for client/server configurations
    - Requires no explicit configuration setup to provide information to connected devices.
    - Easy to Deploy

- ## Advertise link properties to upstream systems.
  - IPv4 organizational-scoped multicast and IPv6 site-local multicast
    - Requires multicast to be enabled in network
    - Requires approval of a new organizational/site-local multicast type by the Internet Assigned Number Authority (IANA).
    - Miss-configurations of organizational-scoped or site-local multicast could result in advertisements in unforeseen global traffic.
  - Unicast advertisements
    - Requires configuration in the modem to send advertisements to known endpoints.
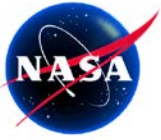
Protocol Signaling

- Advertisements are sent periodically or as notifications of link-layer events (such as rate changes) when they happen
  - A link rate changes due to a coding change, or the link and its interface go up or down
- The modem should send periodic advertisements about link conditions, in case new devices have been connected
- A device attached to the local link must be able to receive link property advertisements via UDP/IP packets sent to the "all routers" multicast address.
- Other network-attached devices may receive advertisements via IPv4 organizational-scoped multicast and IPv6 site-local multicast or unicast advertisements.

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Protocol Block Type

```
                   1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---
|      UDP source port          |       UDP destination port    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ B T
|        UDP length             |         UDP checksum          | L Y
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ O P
|  Block Type ID (Rate Type 1)  |              Length           | C E
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ K
|  no. of links | link rate size| modem flags (15 bits unused)|S|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ---
|               unique modem interface identifier               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                MTU            |   interface flags |B|F|4|6|U|I|  S
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  U
|     current link rate (varies) - 32 bits is rate size of 1    |  B
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  -
|      minimum supported rate - 32 bits is rate size of 1       |  B
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  L
|      maximum supported rate - 32 bits is rate size of 1       |  O
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+  C
|  IPv4 address of modem's local link interface, if 4 flag set  |  K
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                                                               |
|  IPv6 address of modem's local link interface, if 6 flag set  |
|                                                               |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
```

Rate Block

- Currently, only one Block Type has been considered, the Rate Block [Slide 11]. Key components of this block type are:
  - The maximum data rate is defined by a 32-bit word corresponding to a limit of 4 Gbps.
  - This format enables one to specify link characteristics simultaneously for both link directions, or separately for the incoming and outgoing links.
  - Link Up / Link Down information is conveyed via the interface flag "U".

- Other possible blocks, not yet defined here, could express measured error rate, current forward error-coding rate, latency (propagation delay, serialization delay), link MTU size, indicate link-level security mechanisms in use, or provide authentication.
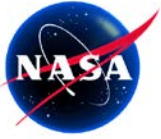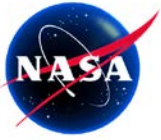
Status

- **Internet Draft submitted to Mobile Operations research group (mobopts)**
    - Modem Link Properties Advertisement Protocol

      (draft-ivancic-mobopts-modemlpa-00)

       expires April 16, 2012
    - Why mobopts ➔ One research topic is to examination of the feasibility of generic mechanisms that allow tighter integration of the link layer with the IP layer for improving handover performance
    - Mobopts has not been very active lately and may recharter, but, this appears to be the most appropriate place to perform this activity
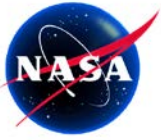
Collaborations

- Anyone or any organization interested in collaborating is welcome – particularly radio developers.
- Google Groups "modemLPA" formed
  - Maillist and archive
  - 13 current members
  - Open to any interested people
    - Contact Will Ivancic (william.d.ivancic@nasa.gov)
- Working with University of Akron
  - Packet Generation of modemLPA protocol for testing
  - Dissector for Wireshark®
  - Possible additions to NASA PERL implementation of Saratoga
- Working with Dr. Shaoen Wu of the University of Southern Mississippi
  - Rate Adaptation on Random Access Wireless Networking
  - Cognitive Wireless Networking Protocols

Summary

- We have presented a simple protocol that can be used to provide upstream devices and applications with downstream link conditions.

- The protocol in this document is described in the context of modem RF link properties, <u>but</u> can also be broadly applied to other scenarios such <u>as</u> cryptographic devices.

- The ability to sense and react to such information is critical for new and developing technologies such as cognitive radios and cognitive networks.